

INTRODUCING LEAFY FLOURY HYBRIDS FOR IMPROVED SILAGE YIELD AND QUALITY

F. B. Glenn
Glenn Seed Ltd.

INTRODUCTION

Since 1986, I have dedicated my career as a corn breeder to the development of silage specific corn varieties for lactating cows. All Leafy silage hybrids marketed to seed companies today have emerged in whole or in part from my breeding program. We have bred either the male or female parent of the hybrid, or both. About 20% of the silage acres that are planted in the USA have our genetics in their seed. Leafy silage varieties are grown in North America, Europe, South America and New Zealand, and enjoy recognition as high-yielding, reliable and nutritious silage producers. Dairy men and seed companies around the world continue to benefit from Leafy's superior silage characteristics.

It is from my breeding program that the industry's first silage specific products emerged in 1992. The hybrids that I have created are a product of my desire to understand and serve the needs of dairy men. It is my experience that Leafy varieties are the most appropriate silage solution in the marketplace today. When planted at recommended populations, Leafy offers dairy men the opportunity to plant less seed and harvest a larger, more reliable and more economic silage crop.

In this paper, I will attempt to situate Leafy within the historic and current context of the silage market. I also hope to demonstrate that Leafy and Leafy floury varieties are fundamentally different from all other silage varieties. Leafy has been bred for characteristics that are inappropriate for commodity grain, and new Leafy hybrids have been advanced further towards silage appropriate characteristics for nearly three decades. As a result, Leafy and Leafy floury varieties behave differently in the field, the silo and the rumen, and require different testing and growing systems.

GRAIN & THE ORIGIN OF SILAGE

Before the 1990's, seed corn companies treated silage as a disposal market for old grain hybrids. At that time, corn silage was not heavily fed to dairy cows and garnered little breeding attention since grain made-up about 95% of the seed corn market. Companies would sell varieties to dairy men that performed poorly in the grain market, or were old and consequently had lower germination rates. In the industry, this mix was known as a silage blend, which was often made up of a different hybrid combination from year to year, as grain hybrid disposal needs changed. Dairy men had little opportunity to produce the same silage varieties again or to apply the experience of neighbours to their own future crop choices. This practice added risk to the already complex business of operating a dairy.

These silage blends were composed of grain hybrids that were bred for high grain yield and for characteristics that supported grain handling. The starch portion of the plant was bred to have a rapid kernel drying rate which was important for reducing the time and energy expended on mechanical drying in the grain industry. Durable kernels were required in order to diminish kernel breakage during shipping and handling since broken kernel fines and dust would lead to loss of product and mechanical issues during grain handling. Additionally, grain was made up of small, high bushel-weight kernels for efficient packing into storage. In terms of plant architecture, these varieties were characterized by stiff stalks that lived longer and did not break before the combine was able to harvest the crop. A higher ear position on the stalk allowed for ease of combining, but resulted in a more lignified product as the plant needed more structure to carry a higher load.

The grain breeder's product can be described as a ripe ear of dense hard kernels on a green solid stalk, but the cultivation and feeding of such a seed product has several obvious problems for use as silage for lactating cows. From a dairy perspective, grain dry-down occurs too rapidly while the stalk remains green. This results in a narrow harvest window and increased risk of reduced crop quality. Also, grain varieties have high recommended population densities, which increases seed costs and raises crop risk during times of moisture stress. The vitreous, hard kernels are not designed to be broken-up during silage harvest, and require additional kernel processing and lengthy ensiling periods. Kernel passage through to the manure is commonplace. After ensiling, the highly lignified silage product has relatively low levels of digestible fiber for milk production. Current commercial Dual Purpose varieties are characterized by these same qualities in today's marketplace.

Now imagine for a moment the ideal silage product – a corn variety that was built specifically for the dairy industry. It would be composed of an appropriate balance of digestible and effective fiber. It would be high in soft, easily digested starch, making it available for bacterial breakdown and easy for the cow to break-up in her mouth and rumen. It would be a large plant that was intended to yield high levels of fiber in addition to high levels of starch. It would have a large harvest window with slow dry down of starch and fiber, and would need little ensiling time before it was ready to be fed.

LEAFY: A REJECTION OF GRAIN-BASED SILAGE

In 1985, Leafy was introduced to corn breeders as the industry's first patented corn characteristic. Leafy is a single dominant gene known to be influenced by many unidentified modifier genes. Its gene action is thought to affect plant growth hormones to allow more leaves above the ear. Non-Leafy corn varieties can produce a maximum of seven leaves above the top ear, though most varieties are characterized by five to six leaves. Plants with the Leafy gene produce eight and more leaves above the top ear. In research fields up to sixteen leaves above the top ear have been noted.

In the 1970's and 1980's, plant physiologists working with early computer modelling software had hypothesized that a corn crop needed more leaf area to increase yield. Higher leaf area can be achieved with more plants per acre or with more leaf area on a plant. The most important leaves on the plant are those above the ear, as they produce the sugars which are stored as starch in the ear. I could see that by breeding Leafy, the ear could be lowered and that we could select from the variation in the number of leaves to produce more above ear leaves. I also saw Leafy as a great breeding opportunity to create unique new lines that could establish Glenn Seed in the corn breeding business.

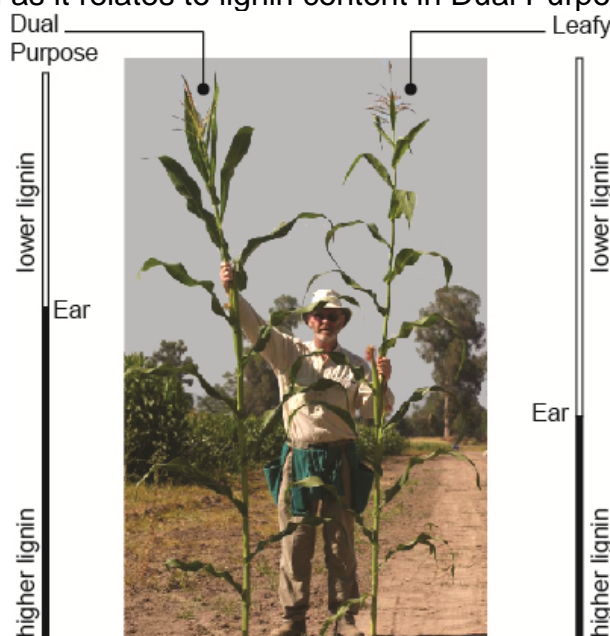
We were able to complete two breeding generations per year by planting a summer nursery in Canada and a winter nursery in Chile. The genetics advanced from the family populations I received, to our selected higher leaf number plants. The new Leafy lines were crossed with suitable parents to make hybrids, but unfortunately these hybrids were failures for commercial grain production. Our Leafies had competitive grain yield, but they were slower drying, had lower test weight and stalk breakage was too high compared to commercial grain. Other breeders who began breeding with Leafy dropped the effort in two or three breeding generations because these new types were not moving towards becoming acceptable grain hybrids.

I saw that what was a failure for grain could be a success for silage, and I decided to breed for silage characters. The first commercial Leafies came to market in 1992 through our customer, the Jacques Seed Company in Wisconsin as TMF106 and TMF94.

My selection criteria for silage hybrids were determined by finding out the specific needs of dairy farmers. Increased understanding of their growing, harvesting, storage and feeding requirements helped to shape the type of Leafy silage varieties that I brought to the marketplace. To produce optimal silage hybrids, I selected for the following characteristics:

- High total yield with high grain content
- Higher above the ear leaf number and taller, more flexible above the ear stalk, which is composed of more digestible fiber
- Lower ear position on the plant, resulting in a decrease in total plant lignin
- Stalks that are adequately strong to stay erect until silage harvest time
- Large ears with kernels that are large and composed of softer, slower drying, lower test weight starch
- Slow kernel maturation and dry down along with slow total plant drying

Figure 1: Ear position as it relates to lignin content in Dual Purpose and Leafy



PLANT DENSITY: UNLOCKING LEAFY'S AGRONOMIC AND ECONOMIC BENEFITS

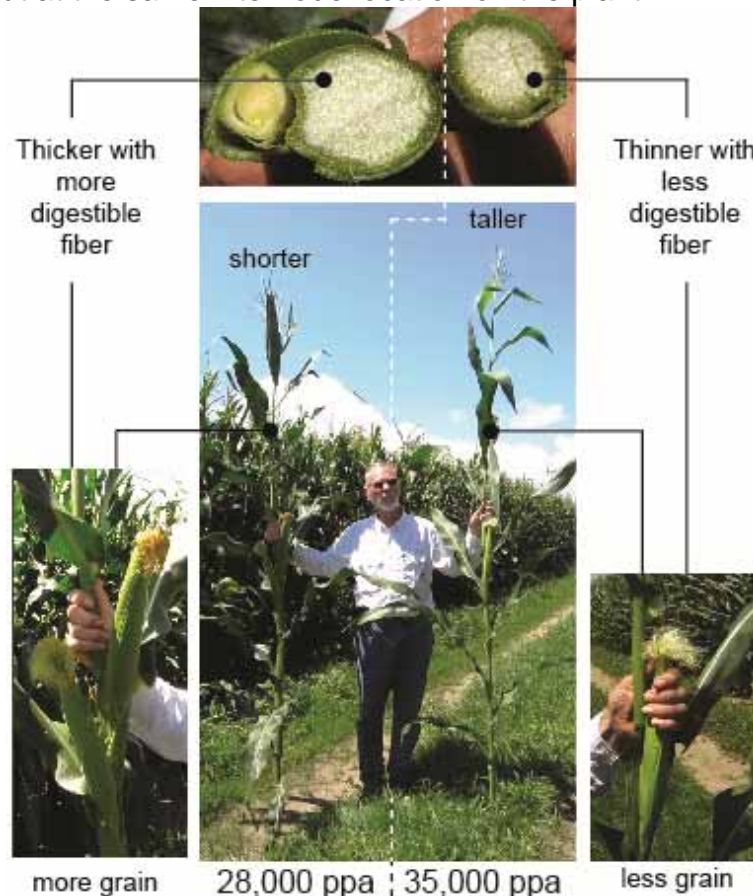
In breeding Leafy we can select giant individuals, and it didn't take long to recognize that they perform better at lower plant populations than those used in traditional grain breeding and testing programs. In a corn breeding nursery, there are open spaces that act as pathways throughout the field, and I could see that the plants that grew next to these open spaces performed better in ear production and in overall size than their more tightly-packed neighbours. I reduced the plant population in our breeding plots more than 20 years ago, and continue to test Leafy hybrids at 28,000 to 30,000 plants per acre (ppa), as opposed to populations of 35,000 ppa often used in grain fields.

In the context of a silage industry where our competitors have higher plant populations in their breeding programs, it has become increasingly important to stress the value of growing Leafies at their intended populations. Increasing density can alter flowering dates and maturity, drought tolerance, standability and overall plant composition, which affects the feeding value of the silage product.

When comparing Leafy plants grown at 28,000 ppa to plants of the same variety grown at 35,000 ppa, the lower population plants have thicker stalks and bigger ears (see Figure 2). The thicker stalks are more digestible and the bigger ears make a silage that contains a higher percentage of overall starch.

In essence, by changing density, the grower changes the nutritional composition of the silage that he is growing. Plants grown at higher densities are more likely to grow taller and skinnier as they compete for light and soil nutrition. This can make the crop susceptible to root and stalk lodging. It also increases the amount of lignin in the plant, while reducing the digestible fiber and starch.

Figure 2: The same Leafy hybrid planted at the recommended population of 28,000 ppa and an overpopulation of 35,000 ppa. In the cross section above, both plants were cut at the same internode location on the plant.



DUAL PURPOSE AND BMR VARIETIES FOR SILAGE

As a response to the emergence of the first silage specific corn varieties in the early 90's, the grain breeding companies devised the concept of Dual Purpose. They claimed that some varieties that were bred for the grain market were suitable for both grain and silage. This development brought dairymen the opportunity to try and then grow the same varieties from year to year, but they were still planting, processing and feeding varieties that were bred for grain use. This use of grain hybrids for silage remains widespread in the marketplace today.

Brown mid rib (bmr) was bred specifically for silage and hybrids were introduced by Cargill in 1994. bmr is most known for its high proportion of digestible fiber and relatively low levels of lignin. This was accompanied by standability problems. Like Dual Purpose, its starch is composed of small, hard, vitreous kernels. While bmr varieties are used by dairymen for its highly digestible fiber and milk output, bmr does not have all the characteristics of an ideal silage specific corn product. While bmr was bred for its high NDFd, and low lignin, this in turn restricts its overall plant yield, as bmr cannot grow as tall or broad as Dual Purpose or Leafy varieties and still retain its structural integrity.

bmr is a smaller plant which produces less silage yield than Dual Purpose or Leafy varieties. In a TMR, bmr rations require the addition of long cut straw (which is high in lignin) in order to keep a rumen mat and slow down rumen passage. The addition of straw to this lower lignin product adds cost, complexity and labour to silage feeding.

Brown mid rib varieties, when grown at their recommended plant population of 30,000-34,000 plants per acre, produce a smaller plant and ear relative to a Leafy grown at 28,000 ppa (Figure 3). The kernels of bmr varieties are vitreous types and along with the selection of new hybrids for improved standability, have resulted in a ripe ear on a green plant, giving hard kernels in the silage. It is recommended to store bmr and grain hybrids for over six months in the silo before beginning to feed.

While bmr has a presence in the marketplace, it should be considered from an economic and management point of view that, the use of bmr entails higher seed costs, higher seeding rate, lower yields, a shorter harvest window, the need for straw in the ration and a longer ensiling period before it can be fed.

Figure 3: Leafy plant, ear and kernel composition compared to bmr



INTRODUCING LEAFY FLOURY: THE NEXT INNOVATION IN SILAGE

Starch supplied from corn silage is an important source of dietary energy for lactating dairy cows, and increasingly, the degree of ruminal starch degradability is attracting the interest of dairy nutritionists and researchers. Leafy hybrids have always been selected specifically for softer kernels types and slower drying rates, and Leafy floury hybrids feature the same Leafy silage characteristics with even more available starch.

Floury, as I have come to call it, appeared twelve years ago in a selection during inbreeding. It was while biting kernels (a technique I use to determine kernel hardness and texture) at harvest time that I first discovered the floury type. The gene may have arisen by natural mutation, but we have found that it is a known recessive gene called

opaque 1. The name opaque refers to the kernels' opacity on a light table – their inability to transmit light. By contrast, grain style kernels are composed of vitreous, or glass-like starch, and do transmit light. The endosperm of our floury kernels is made entirely of white flour type starch – open structure and soft. A thin layer of harder yellow starch occurs just under the outer layer giving kernel integrity for seed handling. I became intrigued by these floury kernels, and hypothesized that as these soft, flour-filled kernels break more easily, then more starch should be available because of increased digestion sites for enzymes and bacteria to convert the starch to sugars. Consequently, starch digestion should be improved.

Test results from Cumberland Valley Analytical Services (CVAS) have since shown that when a parental inbred that contains the opaque 1 gene is crossed with one of our Leafy parental inbreds, the seven hour starch digestibility is 5% to 12% higher than current Leafy hybrids. Additionally, a comprehensive evaluation of one of our floury hybrids has revealed that “nutrients were more readily available to the rumen microorganisms as seen in a faster initial rate of fermentation” than a vitreous control type (S. Nellis, 2012). Researchers are just beginning to study our Leafy floury hybrids.

In the 12 years since I discovered opaque 1, my research program has had more than 20 generations of breeding and selection with floury, resulting in the creation of robust floury inbred lines. Our advancing hybrids have good resistance to stalk and ear molds that could cause mycotoxins. We test about 600 new hybrids per year across western Ontario; the best of which make their way to the market place through our seed company customers.

Figure 4: Ear with kernel tops shaved off to reveal 25% full floury kernels (white) and 75% normal Leafy kernels (white surrounded by yellow).



Opaque 1 is a recessive gene, so when pollinated with a vitreous type, a mix of vitreous and floury kernels is formed. In the silage production crop, these hybrids produce an ear with the segregation of the dominant and recessive kernel types resulting in 25% of the kernels on the ear being opaque. The remaining 75% are characteristic of Leafy hybrids' softer starch.

With Leafy floury products coming to the market place, the next logical step was to conduct a milk study. I chose University of Wisconsin researcher Dr. Randy Shaver, as UW has a great dairy research facility and Dr. Shaver has been the primary developer of the Milk 2000 and Milk 2006 formulas. He and Pat Hoffman are interested in starch digestion in the rumen. Shaver's milk formulas are developed to use near infra-red

(NIR) measurement on fresh and ensiled samples to predict variety performance equated to milk yield. This formula takes starch content into account, but not starch digestibility. Joe Lauer is the UW extension specialist involved in state testing of silage hybrids in Wisconsin and has steadfastly resisted planting Leafies at our recommended rates. When our Leafies are planted in the Wisconsin trials and strip tests, they are planted at densities used for bmr and Dual Purpose which often results in the production of less starch and therefore less calculated milk per acre. The choice of the University of Wisconsin Arlington Dairy Research Centre for this study was partly to encourage examination of starch digestibility and plant population.

We selected a commercial Leafy floury hybrid, a bmr hybrid, and a Dual Purpose hybrid for the study. Each were planted at their recommended population densities and harvested as near possible to 65% moisture, 35% dry matter. Harvest occurred using a chopper with a kernel processor, and the products were ensiled in bags. CVAS evaluation was used with the goal of balancing the three rations to allow for the maximum inclusion of corn silage to maintain milk production. Feeding began 30 days after harvest. This milk study should be submitted for publication by the end of 2013.

DAIRY NICHE MARKET CONCEPTUAL PRODUCTS

In the course of selecting and breeding silage specific varieties with the Leafy and opaque 1 genes, I have encountered exciting variations for use in other markets. I would like to introduce three new concepts that we are developing for dairy niche markets.

- **Dry cow and heifer specific silage:**
I have selected a Leafy hybrid which has so many leaves above the ear that the silks and kernel ovules are too old by the time the community of plants produces pollen. This results in lower kernel set – hence lower starch. The plants are big and are grown at a population of 28-30,000 plants per acre. The stalks are flexible and adequate to stand until silage harvest. The yield is high and the silage product is appropriate to feed to dairy cows in late pregnancy – lower in starch than the silage wanted for milking cows.
- **100% floury Leafy silage for lactating cows:**
We can now make hybrids which are floury in both parents so the hybrid has 100% floury kernels (Figure 6, below). We have had three seasons of screening these hybrids at our home location. This would make a very hot silage and we have to explore how to balance such a ration, but it could result in even greater inclusion of corn silage in the TMR.
- **100% floury Leafy or non-Leafy hybrid for high moisture corn (HMC):**
After three years of hybrid screening, our best hybrids are about 80% of the grain yield of the best grain hybrids. Since the starch is more digestible in the rumen, much less HMC would need to be fed resulting in more economic value. In theory, the same silo would hold more milk. Floury's soft kernels offer a slow drying rate for harvest advantage and a high grain or CCM yield.

HMC producers are particularly concerned with the susceptibility of the grain to ear molds that would cause mycotoxins in the harvested products. We have selected and advanced only the germplasm which has the most resistance to ear molds. I am confident that our floury hybrids are much better for producing low mold-contaminated product than many current grain corn hybrids. We are testing 80 new 100% floury hybrids in 2013. The starch digestibility of the HMC concept types will be evaluated for highest yield and best standability. We hope to have commercial HMC hybrids in the near future.

Figure 5: Leafy hybrid for Heifer Specific Silage



Figure 6: Ear with kernel tops shaved off to reveal 100% full floury kernels.



CONCLUSION

The Leafy Silage breeding program that I have led since 1986 has been a feed focused one. The continuity of the vision that supports these breeding efforts, combined with the small size of my company has allowed for the creation of innovative, finely tuned, well tested silage products which serve dairy producers. Leafy varieties continue to lead silage specific product development in the industry.

REFERENCES

S. Nellis, 2012, *Comprehensive Evaluation of Unknown Flourey Hybrid (Glenn Seed Ltd.)*, UW Madison, Department of Dairy Science.